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RESPONSE TO USEPA STATEMENT OF POSITION

Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

Submitted To:	United States Environmental Protection Agency
Submitted By:	AMEC Geomatrix, Inc. Scottsdale, Arizona
Date:	October 25, 2010
Project No.:	0146821030

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ATTACHMENTS

CRANE CO. REPLY TO USEPA STATEMENT OF POSITION

Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

1.0 INTRODUCTION

Crane Co. has prepared this reply to the October 18, 2010 United States Environmental Protection Agency's (USEPA) Statement of Position (Statement of Position) regarding the Northeast Injection Well Dispute for the Phoenix-Goodyear Airport-North Superfund (PGA-North) Site (Site). This reply has been prepared as part of the ongoing formal dispute consistent with Paragraph 88 of the April 2006 Partial Consent Decree. In the Statement of Position, USEPA contends that its evaluation of the northeast plume and remedy calls for a minimum of five injections wells to ensure an effective hydraulic barrier.

In this reply, Crane Co. provides a rebuttal for the Statement of Position to demonstrate why the USEPA's position is arbitrary, hypothetical, technically flawed, and not supported by actual field data collected from the Site. In addition, Crane Co. will continue to demonstrate that the existing two injections wells (IA-11 and IA-12) already have formed an effective hydraulic barrier as evidenced by actual field data and analysis. The data provided with this reply is current through October 15, 2010 and was provided to USEPA in our weekly update on October 20, 2010. As stated in Crane Co.'s *Dispute Resolution Statement of Position*, Crane Co.'s technical analysis is not predicated on the groundwater flow remaining to the north or northwest. The protective analyses provided by Crane Co. and its technical consultants, conservatively assumes a northeastward flow condition (worst-case condition) along Dysart Road north of I-10.

Crane Co. will clearly demonstrate, through multiple lines of evidence, that three injection wells will maintain an effective hydraulic barrier west of Dysart Road and be protective to local water supplies. Further, three injection wells will provide more than adequate operational flexibility and coupled with extraction well EA-07 will maintain the already existing hydraulic barrier for the containment of the Subunit A trichloroethene (TCE) plume in the northeast area.

2.0 USEPA'S DETERMINATION FOR FIVE INJECTION WELLS IS ARBITRARY

USEPA's Statement of Position states on page 5: "By April 2010, EPA had determined that 5 wells were required as a minimum to achieve hydraulic containment." However, the first time either USEPA or its technical consultants provided Crane Co. any technical assessment or analysis to justify that conclusion was months later during the August 4, 2010 PGA-North Quarterly Technical meeting. Innovative Technical Solutions, Inc. (ITSI) and CH2M Hill provided four technical memoranda dated August 23, August 24, August 30, and October 13, 2010 in a belated attempt to justify USEPA's earlier decision for five injection wells. From this, it is noted that:

- USEPA's analysis was performed after the determination that five injection wells were required as a minimum. This clearly demonstrates that USEPA's requirement of five injection wells was not based on any technical analysis and was arbitrary.
- USEPA's technical analyses presented at and after the August 4, 2010 PGA-North Quarterly Technical meeting is hypothetical, technically flawed, and does not utilize all existing relevant field data collected from the Site.

USEPA's Statement of Position also states on page5: "EPA carefully calculated the appropriate number of injection wells using standard ground-water techniques, including aquifer tests, equations on well hydraulics, and ground-water flow models". To date, the USEPA has not provided a single flow model simulation or result to substantiate that conclusion. The USEPA Statement of Position presents Attachments 5, 6, and 7 as three efforts at "estimating hydraulic conditions from aquifer tests using well-hydraulic equations." The analyses present an unrealistic oversimplification at best and rely on numerous technically flawed underlying assumptions that do not reflect the complex heterogeneous nature of the local Subunit A aquifer.

2.1 TECHNICAL FLAWS IN ANALYSIS OF USEPA'S STATEMENT OF POSITION ATTACHMENT 5

USEPA's Statement of Position Attachment 5, *Hydraulic Gradient/Flow Vector Evaluation and Hydraulic Mounding Analysis for Injection Wells (IA-11, IA-12, IA-13, IA-14, IA-15, and IA-10) at the Phoenix-Goodyear Airport North Superfund, Goodyear, Arizona*, dated August 24, 2010 (ITSI, 2010a), contains a general disclaimer that, "There are numerous assumptions and limitations associated with Theis Equation and Thiem Equation" and that "applications of these two equations to calculate the groundwater mounding and radius of influence are limited by these assumptions."

Granted all these assumptions, USEPA's calculations are still incorrect. The calculation at the bottom of page 8 of Attachment 5 for radius of influence (ROI) analysis at injection well IA-11 uses an incorrect aquifer saturated thickness in its computation. For an injection scenario, the aquifer saturated thickness is the ambient saturated thickness plus the mounding created by the injection well. The computation performed on page 8 (and in fact all other such computations) subtracts the mounding amount from ambient thickness (as if the equation were applied to drawdown due to pumping and not mounding due to injection). With the correct saturated thickness inserted in the equation for ROI at injection well IA-11 for an injection rate of 333 gallons per minute (gpm) (negative value of pumping required for injection), the computed ROI is 2,768 feet, not 850 feet as stated in Attachment 5. The equation using the correct saturated thickness and a negative Q value representing injection is presented below;

$\ln(r_2/0.5) = \{[(60 \text{ ft} + 1 \text{ ft})^2 - (60 \text{ ft} + 8 \text{ ft})^2] \times 3.14 \times 195 \text{ ft/day}\}/[(-333 \text{ gpm} \times 60 \text{ minutes/hour} \times 24 \text{ hour/day})/7.48 \text{ gallons/ft}^3] = 8.62$

then, $2r_2 = e^{8.62} = 5{,}536$ ft, and $r_2 = 2{,}768$ ft

Even with the calculation errors, the USEPA's own analysis demonstrates the flaw (see Table 1 of Attachment 5) that five wells are better than three. The analysis shows that a three-well situation would have a maximum ROI of 850 feet per well (at an injection rate of 333 gpm per well), while a five-well situation would have a maximum ROI of 497 feet per well (at an injection rate of 200 gpm per well). Since the protective zone around each well is twice its ROI, the protective zone for three wells would be 3 x 2 x 850 feet = 5,100 feet. Similarly, the protective zone for five wells would be 5 x 2 x 497 feet = 4,970 feet. The USEPA's own analyses show that a three-well situation is more protective and creates a wider hydraulic barrier than a five-well situation considering the finite volume of water available for injection.

2.2 TECHNICAL FLAWS IN ANALYSIS OF USEPA'S STATEMENT OF POSITION ATTACHMENT 6

Similar to Attachment 5, USEPA's Statement of Position Attachment 6, *Radius of Influence Analysis for Injection IA-12 at the Phoenix-Goodyear Airport North (PGAN) Superfund, Goodyear, Arizona,* dated August 30, 2010 (ITSI, 2010b), contains a general disclaimer that, "There are numerous assumptions and limitations associated with Thiem Equation" and that "The applications of this equation to radius of influence estimation are limited by these assumptions." The assumptions or the impact of these assumptions are not considered as a part of USEPA's evaluations.

The computations in Attachment 6 are invalid, because they assume a steady-state solution for two separate mounding events each of which occurred over a period of less than 12 hours. Given the assumption that the aquifer system had approached steady-state conditions, the calculation on page 2 of Attachment 6 for hydraulic conductivity (K) is incorrect because inconsistent units were used in the equation variables. The value for the injection rate (525 gpm) was not converted to cubic feet per day (ft^3/day). The calculation using the correct units for the injection rate is presented below;

$K = [(525 \text{ gpm} \times 60 \text{ minutes/day} \times 24 \text{ hours/day} / 7.48 \text{ gallons/ft}^3)/3.14 \times ((80 - 7.5)^2 - (80 - 9.8)^2)] \times \ln(70/30) = 8{,}973{,}986 \text{ ft/day}$

Using the correct units results in a ridiculously large calculated value of K, about 8,950,000 ft/day.

2.3 TECHNICAL FLAWS IN ANALYSIS OF USEPA'S STATEMENT OF POSITION ATTACHMENT 7

USEPA's Statement of Position Attachment 7, *Evaluation of Injection Testing Data from Injection Wells IA-11 and IA-12, Phoenix-Goodyear Airport North (PGAN) Superfund, Goodyear, Arizona,* dated October 13, 2010 (ITSI, 2010c), concludes that the water level increases in monitor wells EPA MW-39A and EPA MW-55A are not related to the injection of groundwater at injection wells IA-11 and IA-12. These conclusions do not agree with the observed water level data. Specifically:

- The USEPA's evaluation of mounding at EPA MW-39A used a water level measurement collected on August 2, 1010 (884.81 feet above mean sea level [ft amsl]). This water level does not represent the closest water level prior to the commencement of injection activities (883.90 feet amsl on 8/19/2010). From August 2 to August 17, 2010 water levels in the northeast area wells (EPA MW-35A, EPA MW-39A, and EPA MW-45A) continued to decrease in response to increased pumping from City of Avondale supply well COA-18 and Irrigation Well IR-3B. Therefore, the USEPA's observation regarding the water level increase at EPA MW-39A is biased low.
- The evaluation states, "…water has to flow uphill to reach well EPA MW-55A, which is impossible." Influences from injection observed at EPA MW-55A are due to the overall increase in groundwater elevation on the ambient flow field, regardless of whether EPA MW-55A is upgradient or downgradient of the injection well – this is basic hydrology.
- The evaluation states, "The calculated travel velocity and travel time do not support the argument." This statement is made without any supporting evidence or documentation. Further, the "travel velocity" and "travel time" referred to by USEPA are not relevant considerations when evaluating influences from injection on the ambient flow field. Rather, the correct consideration is the average linear velocity and associated arrival time of water level increases resulting from increasing pressure caused by increasing hydraulic gradients from the water injection. USEPA's reliance on those irrelevant factors again demonstrates the lack of understanding of basic hydrology.

The USEPA's assessment that a one-foot mound is necessary to create an effective hydraulic barrier and that gaps will exist if this is not realized is without any technical justification. The actual field data demonstrates that the injection of groundwater and associated water level increases in monitor wells EPA MW-39A, EPAMW-55A, EPA MW-45A, EPAMW-43A, EPA MW-30A and EPA MW-34A have maintained a west to northwest flow direction and has created an effective hydraulic barrier which is protective to local water supplies. In addition, groundwater extraction at EA-07 which also has an impact on northeast plume containment is never once analyzed or credited by the USEPA Statement of Position as part of the northeast containment strategy.

Attachment 7 concludes that water level increases in monitor wells EPA MW-30A, EPA MW-34A, EPA MW-35A, EPA MW-39A, and EPA MW-55A are not related to the injection of groundwater at IA-11 and IA-12. These conclusions do not agree with the observed water level data. Specifically:

- Hand-measured water level data show that water levels in EPA MW-39A (Attachment A1) started to indicate a discernable influence from injection of groundwater on approximately August 27, 2010 (884.30 ft amsl), with an increase of 0.40 feet over pre-injection conditions.
- Hand-measured water level data show that water levels in EPA MW-55A (Attachment A1) started to indicate a discernable influence from injection of groundwater on approximately September 20, 2010 (883.28 ft amsl), with an increase of 0.53 feet over pre-injection conditions.
- Hand-measured water level data show that water levels in EPA MW-30A (Attachment A2) started to indicate a discernable influence from injection of groundwater on approximately September 1, 2010 (881.76 ft amsl), with an increase of 0.46 feet over pre-injection conditions.
- Hand-measured water level data show that water levels in EPA MW-34A (Attachment A2) started to indicate a discernable influence from injection of groundwater on approximately September 7, 2010 (881.69 ft amsl), with an increase of 0.41 feet over pre-injection conditions.

The arrival time for the water level increases in these wells are consistent with the calculated average linear velocities and observed arrival times for water level increases in PZ-11, PZ-12, EPA MW-45A, and EPA MW-43A (Attachment B). For example:

- The observed and calculated average linear velocities from injection well IA-12 to PZ-11 and IA-12 to PZ-12 are from 1,584 feet/day and 1,239 feet/day, respectively.
- Similarly, the observed and calculated average linear velocities from injection well IA-12 to EPA MW-45A and from injection well IA-11 to EPA MW-43A are from 178 feet/day to 180 feet/day, respectively.

The USEPA conclusion that the water level increases in monitor wells EPA MW-30A, EPA MW-34A, EPA MW-35A, EPA MW-39A, and EPA MW-55A are related to a regional water level rise is not supported by the actual field data. If this USEPA hypothesis was true, then all wells, including background monitor wells EPA MW-16A, EPA MW-18A, EPA MW-20A, and EPA MW-31A would show similar magnitudes of increase over the past two months. The table below compares the groundwater elevation data derived from hand-measured water levels collected on October 15, 2010 to pre-injection groundwater elevations. In order to determine the influence the regional increase in groundwater elevations has on the monitor wells in the area of injection at IA-11 and IA-12, changes in groundwater elevations for background monitor wells EPA MW-16A, EPA MW-18A, EPA MW-20A, and EPA MW-31A are also presented. The average regional increase observed over this same time period in these four background monitor wells is 0.12 feet. To be conservative, the column on the far right indicates the increase in groundwater elevation from the influence of injection at IA-11 and/or IA-12 minus the maximum observed (0.25 feet in EPA MW-31A) increase in water level due to regional influences. These data clearly demonstrate that the increase in groundwater elevations observed in the monitor wells/piezometers listed is a direct result of groundwater injection at IA-11 and IA-12 and the creation of a hydraulic barrier in this area.

Injection Well Area	Well ID	Pre-injection Water Elevation (ft amsl)	Oct 15, 2010 Water Elevation (ft amsl)l	Increase in Water Level (feet)	Increase in Water Level minus Max Regional Increase (feet)
IA-11	EPA MW-30A	881.30 (8/4/2010)	882.40	1.10	0.85
	EPA MW-34A	881.28 (8/17/2010)	881.99	0.71	0.46
	EPA MW-43A	881.13 (8/4/2010)	883.24	2.11	1.86
IA-12	EPA MW-35A	883.27 (8/4/2010)	883.84	0.57	0.32
	EPA MW-39A	883.90 (8/19/2010)	885.06	1.16	0.91
	EPA MW-45A	886.24 (8/2/2010)	888.74	2.50	2.25
	EPA MW-55A	882.75 (8/3/2010)	883.64	0.89	0.64
	PZ-11	887.73 (8/5/2010)	896.42	8.69	8.44
	PZ-12	887.74 (8/5/2010)	895.48	7.74	7.49
Background Monitor Wells	EPA MW-16A	882.20 (9/22/2010)	882.09	-0.11	--
	EPA MW-18A	881.54 (8/3/2010)	881.67	0.13	--
	EPA MW-20A	878.82 (8/2/2010)	879.04	0.22	--
	EPA MW-31A	881.60 (8/2/2010)	881.85	0.25	--

3.0 NEED FOR CREATION OF OVERLAPPING MOUNDS

USEPA's Statement of Position states on page 6: "A hydraulic barrier is only successful if the injected water creates overlapping mounding or does not have gaps where contamination can move past the injection points." In addition, Attachment 5 assumes, without any further technical justification, that "…the area of one foot rise is important to build significant hydraulic barrier for an injection well…" However, on page 4 of the Statement of Position, the USEPA references the document entitled, *Pump-and-Treat Ground-Water Remediation: A Guide for Decision Makers and Practitioners* (USEPA, 1996) to convey what the proper utilization of an extraction system in combination with a hydraulic barrier entails. Section 5.1.2 of this document states, “The primary purpose of a pressure ridge (i.e., hydraulic barrier) is to <u>increase the hydraulic gradient</u> and hence the velocity of clean ground water moving into the plume…” In fact, the document does not mention “a one foot barrier as being important to building a significant hydraulic barrier”. As stated in the Crane Co. *Dispute Resolution Statement of Position*, dated September 27, 2010 (AMEC, 2010) “Because USEPA’s assumption (one foot rise in groundwater elevation), which is the sole technical basis for the position that five injection wells are required, is incorrect, USEPA’s position is not technically defensible and is arbitrary”.

As presented in Figures 3, 4, and 6 of the Crane Co. *Dispute Resolution Statement of Position*, current site specific groundwater elevation data supports that water levels within Subunit A along Dysart Road are elevated in comparison to monitor wells to the west. Therefore, it is clear that the current hydraulic barrier created by only two injection wells IA-11 and IA-12 is effective at <u>increasing the hydraulic gradient</u> and hence increasing the velocity of clean ground water moving west into the plume. Additionally, this hydraulic barrier will be further enhanced and provide additional protection to local water supplies with the addition of injection well IA-13 and continued development of the capture zone of extraction well EA-07.

4.0 RADIUS OF INFLUENCE OF EXISTING INJECTION WELLS

The site specific data from monitor wells and piezometers clearly demonstrates that the radius of influence for the two existing injection wells (IA-11 and IA-12) is greater than estimated in the analysis from USEPA. The corrected USEPA calculations suggesting a 2,768 foot ROI in 90 days at injection well IA-11 with an injection rate of 333 gpm corroborates with the observed field data. This conclusion is further substantiated by an analysis of the volume of water injected to date in IA-11 and IA-12 which matches closely to the volume of water that would be needed to raise water levels to the amount observed by the current field data.

As of October 11, 2010 a total of 57,521,388 gallons (176.5 acre-feet) of groundwater has been injected at IA-11 and 1A-12. An evaluation (Attachment C) of the amount of water injected relative to available pore space was conducted to determine if the observed mounding in monitor wells in the northeast area is reasonable. To determine the predominant direction of groundwater flow that would occur from groundwater injection at IA-11 and IA-12, the October 2010 hand-measured water levels were used to determine flow direction and flow vectors. The shape of the injection front was estimated to be parabolic with the majority of the injected water flowing downgradient from each injection well. To ground truth the zone of influence of the observed injections in order to calculate a realistic volume, the leading edge of each parabola generally matches the observed water level mounding as of October 15, 2010. A porosity of 30% (which is consistent with the deposits of Subunit A) was used to determine the available pore volume. The results of this evaluation suggest that the water injected into IA-11 and IA-12 would uniformly fill the parabolic areas to depths of 1.56 feet and 1.66 feet, respectively. This is in general agreement with the observed mounding and confirms the radius of influence currently developed by injection wells IA-11 and IA-12 and measured in local monitor wells.

5.0 SUMMARY OF CURRENT MONITORING DATA SINCE START UP OF IA-11, IA-12 AND EA-07

As referenced, the start-up and initial injections at IA-11 and IA-12 used only water extracted from EA-06, but now using water from EA-06 and EA-07 have demonstrated dramatic changes in the field observed water levels in the northeast area. The extraction of groundwater from EA-07 and the re-injection of that water at injection wells IA-11 and IA-12 have enhanced the hydraulic barrier along Dysart Road even further. As expected, as EA-07 continues to pump, the changes in water levels and other hydraulic containment effects are continuing to develop.

USEPA's Statement of Position states on page 7: "Although groundwater levels in the 3 eastern monitoring wells (MW-35A, MW-45A, and MW-39A) peaked in early summer 2010, they have steadily decreased since July 2010, indicating that the northwest shift in groundwater flow is likely temporary." While it is true that water levels in these wells peaked in June 2010 and declined through August 2010, since the injection of groundwater commenced at IA-11 and IA-12, water levels in these wells have steadily increased, as indicated by the hand-measured water levels and hydrograph presented in Attachment A1.

In summary, the field observed hand-measured water level data demonstrate the current and continuing injection at IA-11 and IA-12 maintained a northwest groundwater flow direction and have developed a full hydraulic barrier west of Dysart Road even without the addition of IA-13. The planned implementation of IA-13 will therefore provide the needed measure of flexibility and redundancy for the system allowing it to continue to be effective and protective to local water supplies in all future flow conditions.

6.0 INJECTION WELL EFFICIENCY AND CONSERVATIVE DESIGN

Crane Co. finds it curious that USEPA would reference a guidance document prepared over 13 years ago to support the conclusion that additional injection wells will be needed due to expected reductions in well efficiency rather than utilize recent site specific data from the PGA-North Site.

- Injection well IA-10 has been operating at the Site for over 2.5 years with no noticeable reduction in well efficiency at a re-injection rate of over 500 gpm. This well is designed and completed almost identically to injection wells IA-11 and IA-12.

- Injection wells IA-11 and IA-12 have two redundant recirculation pipes that were specifically designed to inject groundwater while rehabilitation work (if needed) is being conducted on the main well screen interval.
- During start-up testing of EA-07, over 800 gpm of flow was injected into injection well IA-11 for a period of approximately four hours and water level data from the well indicates the well still had additional capacity for re-injection. Given the expected flow rates from EA-06 and EA-07 long term – the actual rate of injection in any of the two existing or one planned injection well (IA-13) will likely not exceed 50% of the well capacity.

In summary – there are no current site specific data supporting the need for additional injection wells to allow for continued operation of the system at full injection rates while the injection wells are being maintained.

7.0 CONCLUSIONS

- It is obvious that USEPA's April 20, 2010 "decision" that five injection wells were required as a minimum to achieve hydraulic containment was not based on any technical analysis. Beginning August 24, 2010, the USEPA submitted the first of four technical memoranda in a belated attempt to justify the necessity of five injection wells. USEPA's technically flawed analyses performed after the determination that five injection wells were required is a transparent attempt to justify its earlier arbitrary decision.

- Field data collected up to October 15, 2010 demonstrate that groundwater injection at IA-11 and IA-12 is and continues to maintain a northwest groundwater flow direction and has developed a full hydraulic barrier west of Dysart Road even without the addition of IA-13. The planned implementation of IA-13 will provide the needed measure of flexibility and redundancy for the system allowing it to continue to be effective and protective to local water supplies in all future flow conditions. Continued operations of extraction well EA-07 will further enhance plume containment.

- Crane Co.'s technical analysis is not predicated on the groundwater flow remaining to the north or northwest. The protective analyses provided by Crane Co. and their technical consultants, conservatively assumes a worst-case eastern/northeastern flow condition along Dysart Road north of I-10.

- Crane Co. will continue to collect and analyze field data – including the new information from the start-up of EA-07 and share it with USEPA. If future field data suggests that conditions are changing and the hydraulic barrier is becoming less effective, Crane Co. will take the necessary steps to augment the system to continue to protect local water supplies.

8.0 REFERENCES

AMEC Geomatrix, 2010. *Dispute Resolution Statement of Position ,Phoenix-Goodyear Airport-North Superfund Site, Goodyear, Arizona*. September 27, 2010.

Innovative Technical Solutions, Inc. (ITSI), 2010a. *Hydraulic Gradient/Flow Vector Evaluation and Hydraulic Mounding Analysis for Injection Wells (IA-11, IA-12, IA-13, IA-14, IA-15, and IA-10) at the Phoenix-Goodyear Airport North Superfund, Goodyear, Arizona*. August 24, 2010.

ITSI, 2010b. *Radius of Influence Analysis for Injection IA-12 at the Phoenix-Goodyear Airport North (PGAN) Superfund, Goodyear, Arizona.* August 30, 2010.

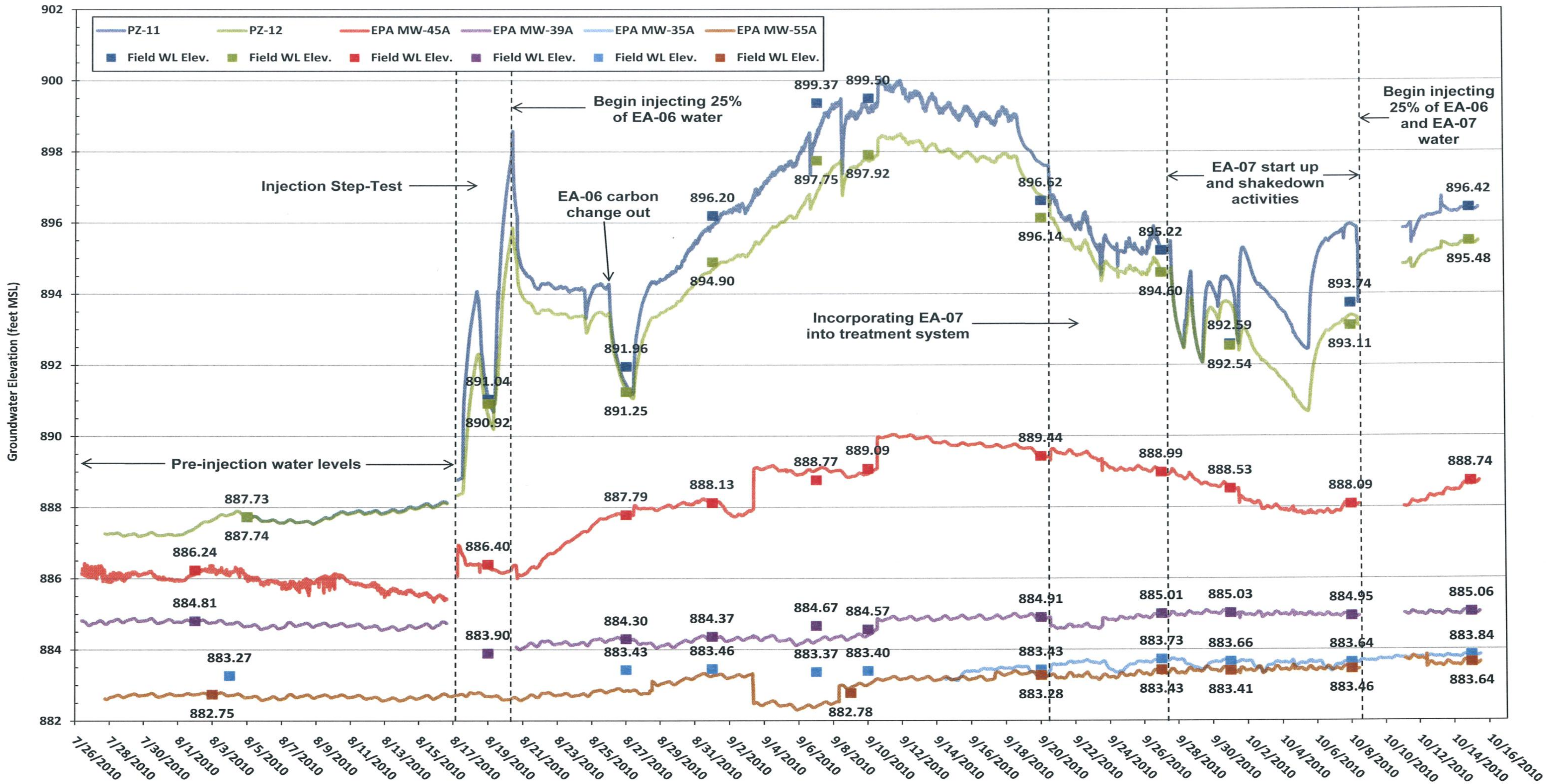
ITSI, 2010c. *Evaluation of Injection Testing Data from Injection Wells IA-11 and IA-12, Phoenix-Goodyear Airport North (PGAN) Superfund, Goodyear, Arizona.* October 13, 2010.

United States Environmental Protection Agency (USEPA), 1996. *Pump-and-Treat Ground-Water Remediation: A Guide for Decision Makers and Practitioners.*

USEPA, 2010. *EPA Region IX Dispute Resolution Statement of Position, Phoenix-Goodyear Airport-North Superfund Site.* October 18, 2010.

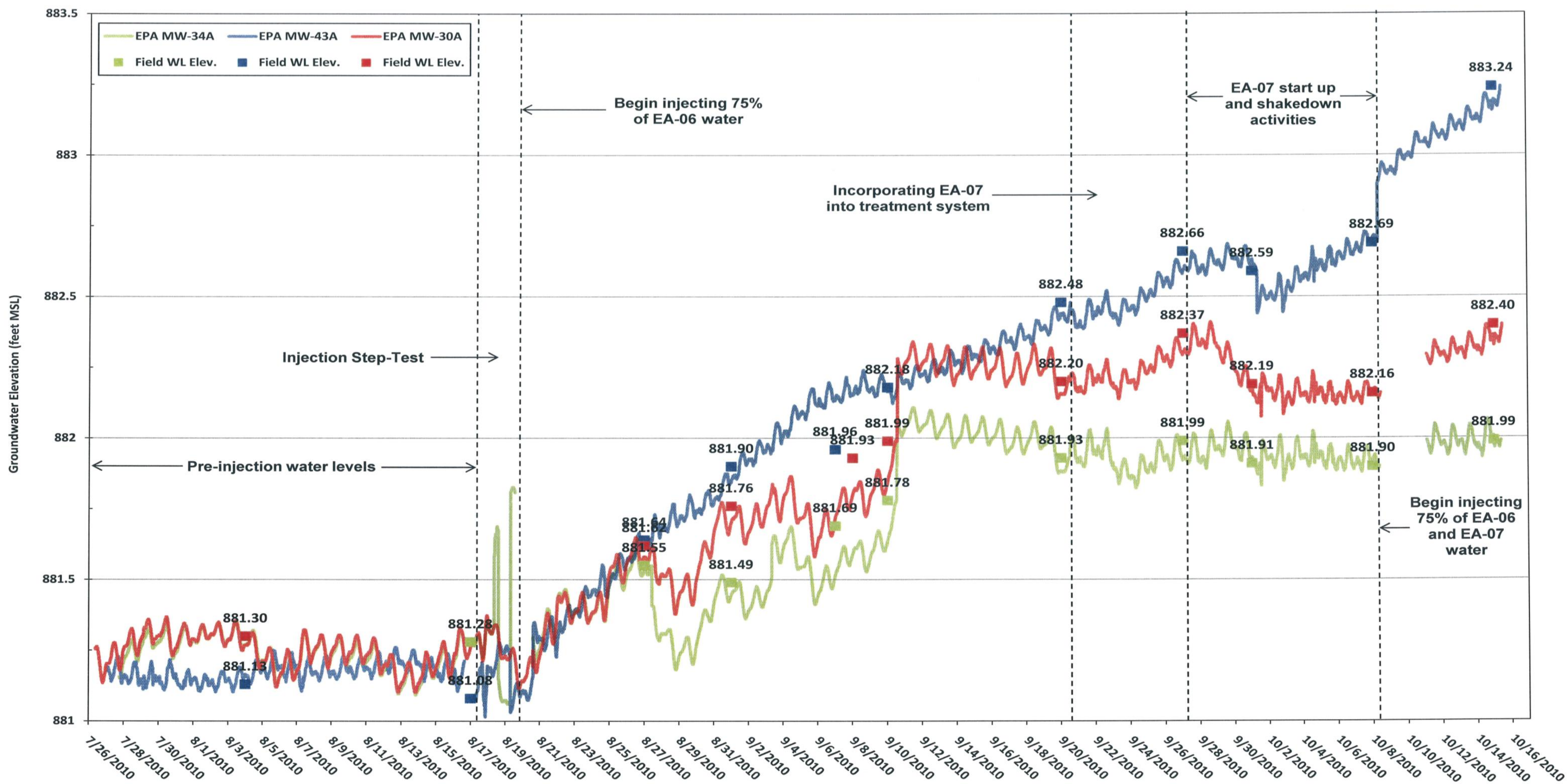
ATTACHMENT A

Observation Wells Response to Injection, IA-11 Area and IA-12 Area



Note: Data after 9/20/2010 is corrected for barometric influence (data from 10/8 to 10/11 missing due to barologger malfunction); EPA MW-35A is an In-Situ transducer and already corrected for barometric influence.

AMEC Geomatrix	OBSERVATION WELLS PZ-11, PZ-12, MW-45A, MW-35A, MW-55A and MW-39A RESPONSE TO IA-12 INJECTION Phoenix-Goodyear Airport-North Superfund Site Goodyear, Arizona	Figure by PRJ Date 10/25/2010	Project No. 0146821030 Attachm,ent A1



Note: Data after 9/20/2010 is corrected for barometric influence (data from 10/8 to 10/11 missing due to barologger malfunction); EPA MW-43A is an In-Situ transducer and already corrected for barometric influence.

Date

AMEC Geomatrix	OBSERVATION WELLS EPA MW-30A, EPA MW-43A, and EPA MW-34A RESPONSE TO IA-11 INJECTION Phoenix-Goodyear Airport-North Superfund Site Goodyear, Arizona	Figure by PRJ	Project No. 0146821030
		Date 10/25/2010	Attachment A2

ATTACHMENT B

Groundwater Velocity Observations and Calculations from Injection Wells IA-11 and IA-12

TECHNICAL MEMORANDUM

To: Dr. Tony Pantaleoni **Date**: October 25, 2010

From: Matrix New World **Project No.**: 10-100-01

Subject: Groundwater Velocity Observations and Calculations from injection wells IA-11 and IA-12

Project: Phoenix Goodyear Airport North (PGA-North) Superfund Site, Goodyear, Arizona

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The October 13, 2010 ITSI Technical Memorandum *Evaluation of Injection Testing Data from injection Wells IA-11 and IA-12, Phoenix Goodyear Airport North (PGAN) Superfund, Goodyear, Arizona* stated that "the calculated travel times do not support the argument that the water level increases in monitor well MW-39A are related to the groundwater injections."

This Technical memorandum was prepared to evaluate the arrival times of water level increases in the northeast area monitor wells (PZ-11, PZ-12, EPA MW-45A, EPA MW-39A, EPA MW-55A, EPA MW-43A, EPA MW-30A, and EPAMW-34A from the injection of groundwater into IA-11 and IA-12 and to refute ITSI's above referenced statement. This analysis included the evaluation of observed arrival times determined from the transducer graphs from PZ-11 (located 33 feet from IA-12) and PZ-12 (located 74 feet from IA-12) and the calculation of average linear velocities from the injection wells to the referenced monitor wells using Darcy's Law.

For the observed arrival times at PZ-11 and PZ-12, the following was evaluated 1) the time it took for the initial deflection of the hydrograph, 2) the time it took for an increase of 0.1 feet (ft) to occur, 3) the time it took for an increase of 0.25 ft to occur, and 4) the time it took for an increase of 0.5 ft to occur. The attached graphs show the following;

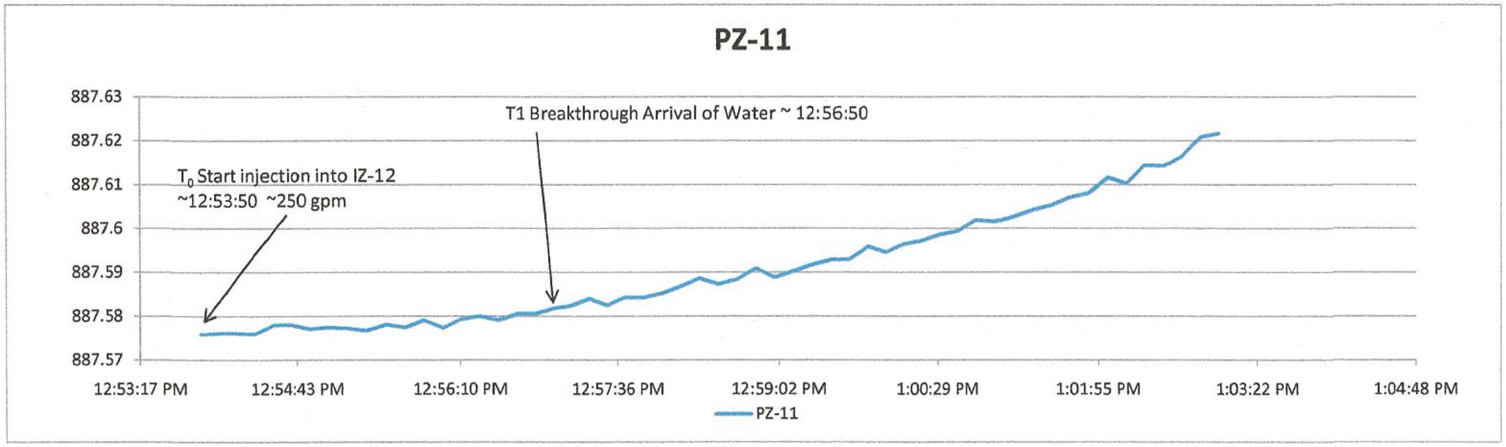
- The initial deflection of water levels in PZ-11 occurred 3 minutes after injection began.
- Water level increases of 0.1 ft, 0.25 ft, and 0.5 ft occurred 13 minutes, 27 minutes, and 30 minutes, respectively, after injection began. This equates to average linear velocities of 1,584 ft /day to 8,196 ft/day.
- In PZ-12 water level increases of 0.1 ft and 0.25 ft occurred at 56 minutes and 86 minutes, respectively. This equates to average linear velocities of 1,239 ft/day and 1,902 ft/day, respectively.

The average linear velocity calculations using Darcy's Law (Attached), utilized a range of hydraulic conductivity (K) values from wells in the northeast area and assumed an effective porosity of 10%. All gradients were relative to the mound height of each injection well. The attached calculations suggest that based on the steep gradients created by the injections, average linear velocities greater than the assumed ambient velocity of 1 ft/day are possible. For example, the attached spreadsheet indicates the following;

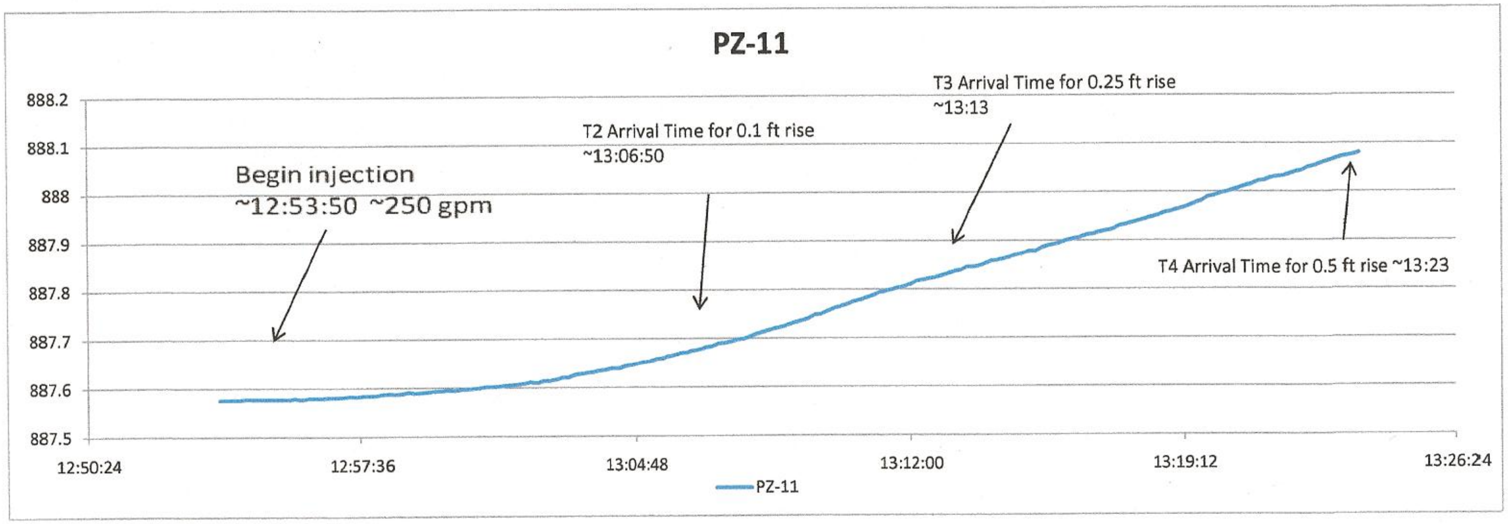
- The calculated travel times for a water level increase at EPA MW-39A from IA-12 ranges from 10.85 days to 32.07 days. This equates to an average linear velocity range from 165.83 ft/day to 56.12 ft/day, respectively. These travel times and velocities are consistent with the water level increases observed in the field for this well.

- The calculated arrival times for a water level increase at EPA MW-45A from IA-12 ranges from 0.95 days to 2.81 days. This equates to an average linear velocity range from 526 ft/day to 178 ft/day, respectively. These travel times and velocities are consistent with the water level increases observed in the field for this well.

The calculations also corroborate the arrival times and increased water levels observed at other select wells in the northeast area. The calculations also suggest that the underlying hydraulic conductivity (K) fields are variable and may be higher than expected.



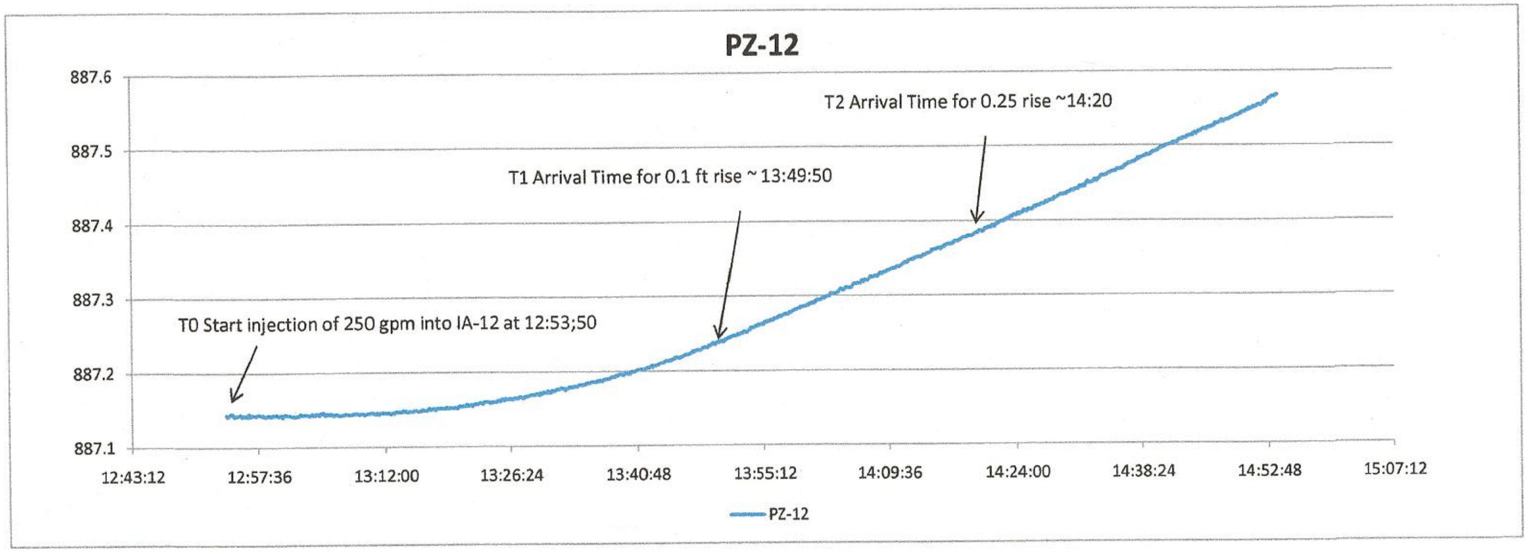
Travel Time for initial breakthrough from IA-12 to PZ-11	3	min		
Distance from IA-12 to PZ-11	33	ft		
Velocity	11	ft/min	**15,840**	**ft/day**



Travel Time for 0.1 ft rise in PZ-11	13.00	min		
Distance from IA-12 to PZ-11	74.00	ft		
Velocity	5.69	ft/min	**8,196.92**	**ft/day**

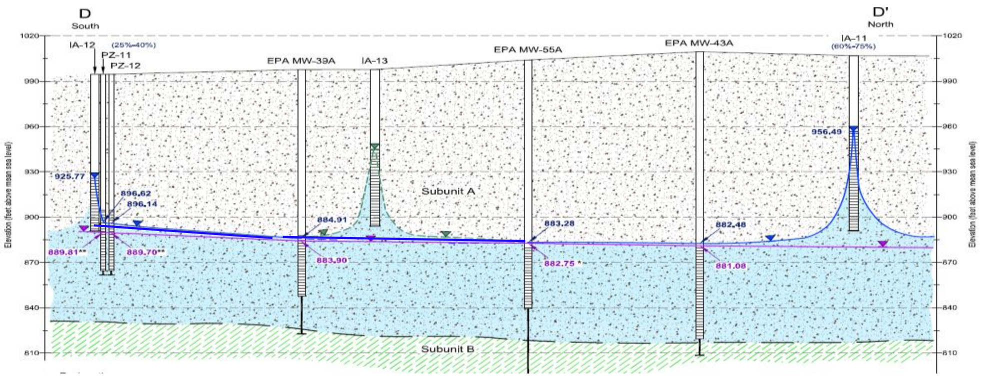
Travel Time for 0.25 ft rise in PZ-11	27.00	min		
Distance from IA-12 to PZ-11	33.00	ft		
Velocity	1.22	ft/min	**1,760.00**	**ft/day**

Travel Time for 0.5 ft rise in PZ-11	30.00	min		
Distance from IA-12 to PZ-11	33.00	ft		
Velocity	1.10	ft/min	**1,584.00**	**ft/day**



Travel Time for 0.1 ft rise in PZ-12	56.00	min		
Distance from IA-12 to PZ-11	74.00	ft		
Velocity	1.32	ft/min	**1,902.86**	**ft/day**

Travel Time for 0.25 ft rise in PZ-11	86.00	min		
Distance from IA-12 to PZ-11	74.00	ft		
Velocity	0.86	ft/min	**1,239.07**	**ft/day**



Darcy's Law

Average Linear Velocity

$V_x = K(dh/dl)/n_e$

K= hydraulic Conductivty
dh/dl = gradient
n_e = Effective porosity

Hydraulic Conductivity (K) in Northeast Area (Ft/day)					
IA-12	**45A**	**43A**	**30A**	**EA-06**	**39A**
80	21	244	151	721	9

Effective Porosity (ne)
0.1

Hydraulic Gradients as of Sep 20, 2010 (dh/dl)							
IA-12/45A	**IA-12/PZ-11**	**IA-12/39A**	**IA-11/43A**	**IA-11/30A**	**IA-11/34A**	**IA-12/PZ-12**	**IA-12/55A**
0.073	0.88	0.023	0.074	0.053	0.049	0.4	0.014

IA-12 to MW-45A		
Distance =	500	ft
K Range	**V (ft/day)**	**Travel Time(d)**
9.00	6.57	76.10
21.00	15.33	32.62
80.00	58.40	8.56
151.00	110.23	4.54
244.00	178.12	2.81
721.00	526.33	0.95

IA-12 to PZ-11			
Distance=	33	ft	
K Range	**V (ft/day)**	**Travel Time(d)**	**min**
9.00	79.20	0.42	600.00
21.00	184.80	0.18	257.14
80.00	704.00	0.05	67.50
151.00	1328.80	0.02	35.76
244.00	2147.20	0.02	22.13
721.00	6344.80	0.01	7.49

IA-12 to MW-39A		
Distance=	1800	ft
K Range	**V (ft/day)**	**Travel Time(d)**
9.00	2.07	869.57
21.00	4.83	372.67
80.00	18.40	97.83
151.00	34.73	51.83
244.00	56.12	32.07
721.00	165.83	10.85

IA-12 to IA-55		
Distance=	3000	ft
K Range	**V (ft/day)**	**Travel Time(d)**
9.00	1.26	2380.95
21.00	2.94	1020.41
80.00	11.20	267.86
151.00	21.14	141.91
244.00	34.16	87.82
721.00	100.94	29.72

IA-12 to PZ-12			
Distance=	74	ft	
K Range	**V (ft/day)**	**Travel Time(d)**	**Min**
9.00	36.00	2.06	2960.00
21.00	84.00	0.88	1268.57
80.00	320.00	0.23	333.00
151.00	604.00	0.12	176.42
244.00	976.00	0.08	109.18
721.00	2884.00	0.03	36.95

IA-11 to MW-43A		
Distance =	1000	ft
K Range	**V (ft/day)**	**Travel Time(d)**
9.00	6.66	150.15
21.00	15.54	64.35
80.00	59.20	16.89
151.00	111.74	8.95
244.00	180.56	5.54
721.00	533.54	1.87

IA-11 to MW-34A		
Distance=	1500	ft
K Range	**V (ft/day)**	**Travel Time(d)**
9.00	4.41	340.14
21.00	10.29	145.77
80.00	39.20	38.27
151.00	73.99	20.27
244.00	119.56	12.55
721.00	353.29	4.25

IA-11 to MW-30A		
Distance=	1500	ft
K Range	**V (ft/day)**	**Travel Time(d)**
9.00	4.77	314.47
21.00	11.13	134.77
80.00	42.40	35.38
151.00	80.03	18.74
244.00	129.32	11.60
721.00	382.13	3.93

	- Denotes a general agreement with observed travel times

ATTACHMENT C

Injected Groundwater and Pore Volume Analysis from Injection Wells IA-11 and IA-12

MATRIXNEWORLD
Enabling Progress

TECHNICAL MEMORANDUM

To: Dr. Tony Pantaleoni **Date**: October 25, 2010

From: Matrix New World **Project No**.: 10-100-01

Subject: Injected Groundwater and Pore volume analysis from injection wells IA-11 and IA-12

Project: Phoenix Goodyear Airport North (PGA-North) Superfund Site, Goodyear, Arizona

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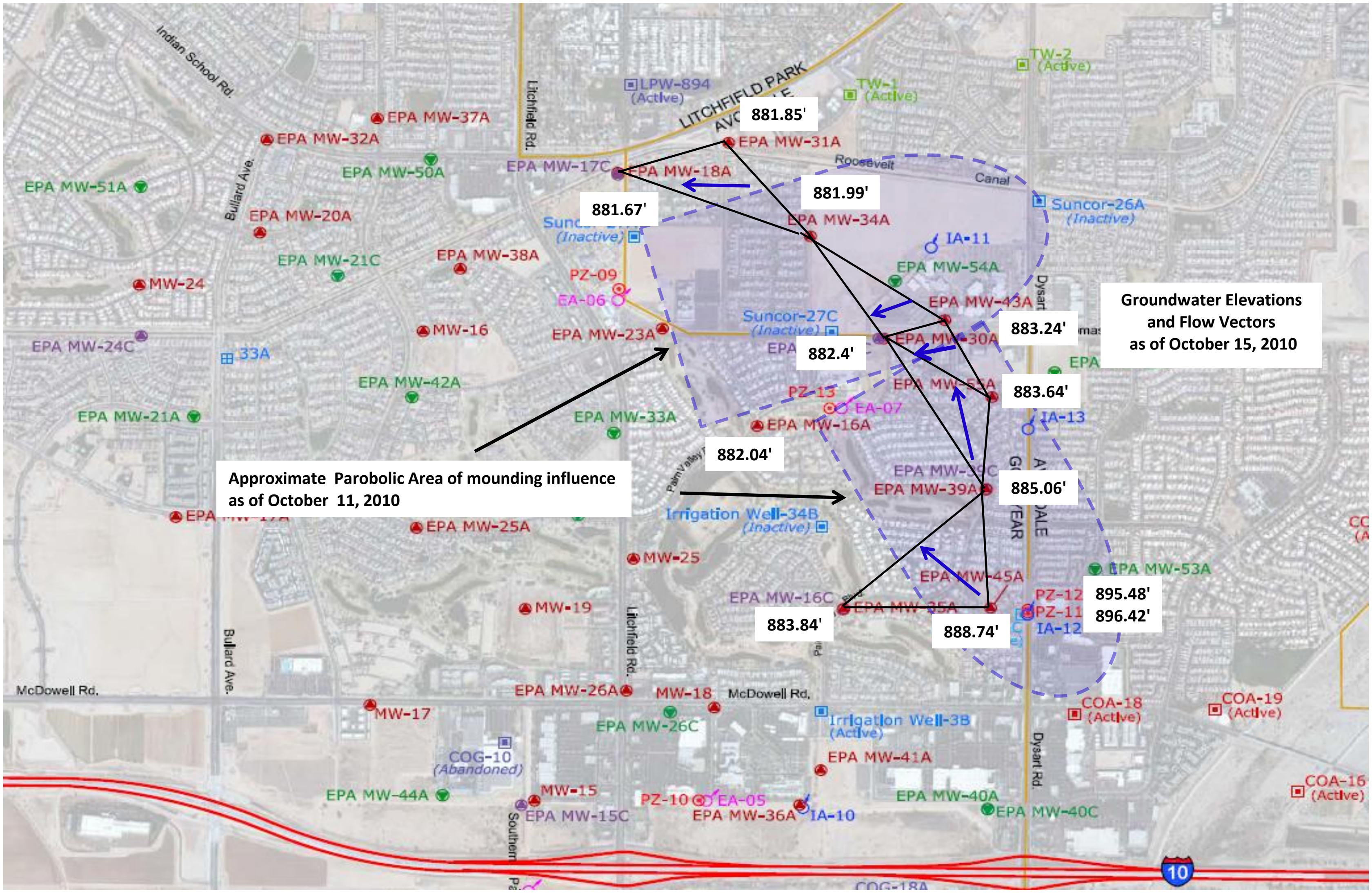
The October 13, 2010 Innovative Technical Solutions, Inc. (ITSI) Technical Memorandum *Evaluation of Injection Testing Data from injection Wells IA-11 and IA-12, Phoenix Goodyear Airport North (PGAN) Superfund, Goodyear, Arizona* stated that "the water level variations at wells(EPA-30A, EPA-34A, and EPA MW-55A) are more likely caused by other impacts" other than the injection at IA-11 and IA-12, and that the "field evidence could not support" the water level increase at EPA MW-39A. ITSI also states that "the radius of influence at IA-12 are in line with EPA's earlier assessment which is 700-900ft (1ft rise) from injection rates of 250 gpm and 525 gpm and approximately 1,100 ft (0.5ft rise) at the same injection rate."

The purpose of this technical memorandum is to determine if the current mounding and observed radius of influence are reasonable based on the volume of water that has been injected relative to the available pore space that is present.

As of October 11, 2010 a total of 57,521,388 gallons (176.5 acre-feet) of groundwater has been injected into Subunit A at injection wells IA-11 and 1A-12. Based on the water level measurements that have been collected on a weekly basis since the injection of groundwater commenced, the radius of influence is much larger than what was assessed by ITSI and the positive effects of the injections are observed at PZ-11, PZ-12 EPA MW-35A, EPA MW-39A, EPA MW-45A, EPA MW-55A, EPA MW-30A, EPA MW-43A, and EPA MW-34A.

To determine the predominant direction of groundwater flow that would occur from groundwater injections at IA-11 and IA-12, the October 2010 hand-measured water levels were used to determine flow direction and flow vectors. The shape of the injection front was estimated to be parabolic with the majority of the injected water flowing downgradient from each injection well. To ground truth the zone of influence of the observed injections in order to calculate a realistic volume, the leading edge of each parabola generally matches the observed water level mounding as of October 15, 2010. A total porosity of 30% (which is consistent with the deposits of Subunit A) was used to determine the available pore volume.

The results of this evaluation suggest that the volume water injected into IA-11 and IA-12 as of October 11, 2010 would uniformly fill the parabolic areas to depths of 1.58 feet and 1.63 feet, respectively. This is in general agreement with the observed mounding.


Groundwater Elevations
and Flow Vectors
as of October 15, 2010
Approximate Parobolic Area of mounding influence
as of October 11, 2010
881.85'
881.99'
881.67'
883.24'
882.4'
883.64'
882.04'
885.06'
883.84'
888.74'
895.48'
896.42'
EPA MW-31A
EPA MW-18A
EPA MW-17C
EPA MW-34A
EPA MW-54A
EPA MW-43A
EPA MW-30A
EPA MW-55A
EPA MW-16A
EPA MW-39A
EPA MW-45A
EPA MW-16C
EPA MW-35A
EPA MW-37A
EPA MW-32A
EPA MW-50A
EPA MW-51A
EPA MW-20A
EPA MW-21C
EPA MW-38A
MW-24
MW-16
EPA MW-23A
EPA MW-24C
33A
EPA MW-42A
EPA MW-21A
EPA MW-33A
EPA MW-25A
MW-25
MW-19
EPA MW-26A
MW-18
MW-17
EPA MW-26C
EPA MW-41A
EPA MW-44A
MW-15
EPA MW-15C
PZ-10
EA-05
EPA MW-36A
IA-10
EPA MW-40A
EPA MW-40C
EPA MW-53A
PZ-12
PZ-11
IA-12
IA-13
IA-11
PZ-09
EA-06
PZ-13
EA-07
LPW-894
(Active)
TW-1
(Active)
TW-2
(Active)
Suncor-26A
(Inactive)
Suncor-27C
(Inactive)
(Inactive)
Irrigation Well-34B
(Inactive)
Irrigation Well-3B
(Active)
COG-10
(Abandoned)
COA-18
(Active)
COA-19
(Active)
COA-16
(Active)
Indian School Rd.
Litchfield Rd.
LITCHFIELD PARK
Roosevelt
Canal
Bullard Ave.
Dysart Rd
McDowell Rd.
10

PGA-N Goodyear Az
Pore Volume Calculation

Area of a parabloa	2/3b*h	Well ID	h (Ft)	b (Ft)
		IA-12	4,700	2,300
		IA-11	5,000	2,700

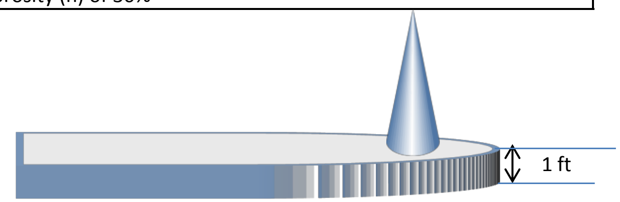
Totalizer Readings -Volume of Water Injected					
	11-Oct-10			7-Oct-10	
Well ID	**Gal**	**ft^3**		**Gal**	**Ft^3**
IA-11	31,521,388	4,214,089.3		26,800,000	3,582,888
IA-12	26,000,000	3,475,935.8		18,500,000	2,473,262
Total	57,521,388	7,690,025.1		45,300,000	6,056,150

	A (ft^2)	**Vt (Ft^3)**	**Vv (ft^3)**
IA-11 Influence	9,000,000	9,000,000	2,700,000
IA-12 Influence	7,206,667	7,206,667	2,162,000
Volumes are based on a parabola with a thickness of 1 foot			
Total Porosity (n) of 30%			

As of Oct 11, 2010 based on assumed parbolic areas of influence and a total porosity of 30%:

The water injected into IA-11 will have a uniform height of **1.58 ft**

The water injected into IA-12 will have a uniform height of **1.63 ft**



r	74 ft
h	29.15 ft

Total volume of injection Cone		
Vt	167,154.40	ft^3
Pore volume of injection cone		
Vv	50,146.32	ft^3

Porosity

$n = V_v / V_t$

Volume

$V_v = n(V_t)$

V_v = Volume of Void

V_t = Total Volume

Volume of a Cone

$V_c = 1/4 \prod r^2 h$

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October 25, 2010

VIA E-MAIL

Bethany Dreyfus
Assistant Regional Counsel
United States Environmental Protection Agency
Region IX - ORC-3
75 Hawthorne Street
San Francisco, CA 94105

RE: Crane Co. / Northeast Injection Well Dispute
Phoenix Goodyear Airport North Superfund Site

Dear Bethany:

Enclosed please find Crane Co.'s October 25, 2010 Reply to USEPA's Statement of Position in connection with the above-referenced dispute.

Sincerely,

QUARLES & BRADY LLP

Joseph A. Drazek

Joseph A. Drazek

JDRAZEK:psm
Enclosure
cc: Chief, Environmental and Enforcement Section, Environment and Natural Resources Division, U.S. Department of Justice (w/encl.)
Jane Diamond (w/encl.)
Catherine Brown (via email w/encl.)
David Wood (w/encl.)
Nicole Coronado (w/encl.)
Augustus I. duPont, Esq. (via email w/encl.)
Anthony D. Pantaleoni, Ph. D. (via email w/encl.)
Anthony D'Iorio, Esq. (via email w/encl.)